

CASE STUDY ON CHARACTERIZATION OF GROUND-WATER CONTAMINATION IN FRACTURED BEDROCK AT THE UNIVERSITY OF CONNECTICUT LANDFILL

Carole D. Johnson, U.S. Geological Survey, 11 Sherman Place Unit 5015, Storrs, CT 06269

Surface- and borehole-geophysical methods together with hydraulic and geochemical data were used to characterize lithology, fractures, and hydraulic properties of crystalline bedrock and to determine the nature and extent of ground-water contamination from a landfill and former chemical-waste disposal pits. The site is in an upland region of the Willimantic River Basin, Connecticut, where bedrock wells are used for domestic water supply. Detection of volatile organic compounds (VOCs) in domestic bedrock wells, in the mid-1980s, led to this ongoing investigation.

Surface-geophysical methods, including electromagnetic induction, two-dimensional direct-current resistivity, square-array direct-current resistivity, and seismic refraction, were used to target potential discharge of contaminants from the landfill for further investigation. Two shallow, electrically conductive anomalies identified near site surface waters were interpreted as leachate plumes. These interpretations were corroborated by field identification of leachate-impacted sediments and surface-water screening, sampling, and analysis. Two sheet-like conductive anomalies were detected in bedrock and were further investigated by borehole drilling, borehole-geophysical logging, and water sampling.

Boreholes were installed to depths of 30 feet in the glacial deposits, and 125 to 300 feet in the bedrock. Conventional geophysical logging; acoustic and optical imaging; single-hole directional radar reflection; flowmeter logging under ambient and pumped conditions; and discrete-interval hydraulic testing, sampling, and monitoring were conducted in 16 bedrock boreholes. Borehole-geophysical methods were used to investigate the conductive anomalies identified by surface-geophysical methods, the location and orientation of fractures that intersect and surround each well, the direction and magnitude of ambient flow in the well, and the transmissive fractures that could provide pathways for contaminant migration.

Discrete-zone monitoring systems in bedrock wells were used to prevent cross contamination, obtain water samples, measure hydraulic head, and assess hydraulic gradients between the bedrock and the glacial-drift deposits. Water samples were collected quarterly and analyzed for VOCs, metals, inorganics and other parameters. The landfill leachate chemical signature includes negative oxidation-reduction potential (ORP), high conductivity, and high iron. Contamination from the former chemical pits is distinguished by chlorinated VOCs (particularly tetrachloroethene) and positive ORP. Discrete-interval head data from individual fractures or fractured zones in the bedrock, collected monthly for a period of two years, showed that over most of the study area the ground-water flow direction remained constant seasonally.

The results of these investigations were evaluated in an iterative and integrated manner to develop a conceptual model of ground-water flow at the site. Collectively, results of the geophysical and geohydrologic investigations identified two contaminant migration pathways - one discharges into a wetland and ultimately dissipates to background levels; and the other seeps into bedrock, where it can be traced based on water chemistry. The migration pathways are oriented north-south, which coincides with a dominant fracture set identified in the geophysical surveys.

The conceptual ground-water flow model of the site was used to inform the selection of remedial alternatives. The University of Connecticut's proposed remedial actions at the landfill site consist of placing a low permeability cap over the landfill, constructing two leachate collection trenches, establishing land use restrictions, and implementing a long-term monitoring program for both the unconsolidated material and the fractured bedrock. The proposed remediation at the former chemical-waste disposal pits consists of placing a low permeability cap over the location of the former chemical-waste disposal pits, connecting additional private houses to the University water system, establishing land use restrictions, and implementing a long-term monitoring program for the fractured bedrock.